Building More with Less...or Just Building More?

Author: Ritayush Suchismita Dey
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Consider any major city skyline you have seen in the last decade. The cranes are taller, the glass is smarter, and the promotional boards around construction sites carry the language of sustainability with growing confidence: low-carbon concrete, net-zero targets, BREEAM Excellent ratings. These are not empty claims. The buildings going up today are, by almost any technical measure, more efficient than those built a generation ago. They leak less heat, draw less power, and are often designed with energy management systems that would have seemed extraordinary twenty years back. The construction industry has invested seriously in improving its own performance, and the numbers show it.

So it is worth asking a question the sector rarely asks of itself: if we are building better, why are we not building more sustainably? In 2023, the buildings and construction industry was responsible for 34% of global CO2 emissions and consumed 32 of the world's final energy. Total emissions from the sector reached 10 gigatonnes of CO2, a figure the UN Environment Programme describes as incompatible with climate goals. Every year since 2016, the gap between the sector's actual trajectory and the path required by the Paris Agreement has grown by an average of 34%. The cranes are still going up. The planet is still warming. The efficiency revolution and the sustainability imperative are not, it turns out, the same thing.

The Myth: As construction becomes increasingly energy-efficient and technologically advanced, its environmental footprint is naturally declining.

The Reality: While modern construction has become meaningfully more efficient, these gains are frequently offset by rising global demand for buildings and infrastructure, growing material consumption, and the challenges of managing construction waste at scale. How efficiently we build matters far less than how much we build, what we build with, and whether those materials remain in circulation after a project ends.

The Steel-and-Glass Argument

Walk through any city centre today, and the evidence of progress seems hard to dispute. Glass facades seal heat in without blocking light. Motion-sensitive lighting systems switch off when rooms are empty. Building management platforms track real-time energy flows and adjust ventilation automatically. Rooftop solar panels feed excess power back to the grid. The vocabulary of modern construction is thick with net-zero commitments, LEED certifications, and promises of carbon-neutral developments by the end of the decade.

The numbers support a genuine story of improvement. According to the Global Status Report for Buildings and Construction 2024-25, published by the UN Environment Programme (UNEP) and the Global Alliance for Buildings and Construction (GlobalABC), global building energy intensity, measured as annual energy consumption per square metre, has fallen by 8.5% over the last decade. Green building certifications have nearly tripled. Investment in building energy efficiency reached USD 275 billion in 2024, contributing to over USD 2.3 trillion in cumulative investment since 2015. New cement chemistries are reducing the carbon intensity of concrete production. Engineered timber is making structural inroads into projects where steel and concrete once went unchallenged. The progress is real, and it matters.

So why does the industry still account for 34% of global CO_2 emissions and consume 32% of final global energy? Why, despite a decade of accelerating efficiency gains, did the sector's absolute emissions reach 10 gigatonnes of CO_2 in 2023, a level the same report describes as incompatible with climate goals? Why has the gap between current trajectories and the Paris Agreement pathway grown by an average of 34% annually since 2016?

The answer lies in a distinction that tends to get lost in headlines about innovation and green building milestones. Efficiency is a measure of what happens per unit: per square metre, per tonne of material, per building delivered. Sustainability is a measure of what happens in total. When the total volume of construction accelerates faster than the per-unit gains, absolute environmental impact grows even as the industry becomes, by its own metrics, more efficient. The construction sector is not unique in this dynamic. It is, however, an exceptionally large illustration of it.

The Improvement in "Efficiency"

It is worth dwelling on the genuine achievements before complicating them. Modern construction has made measurable progress across several dimensions, and dismissing that progress would be as misleading as overstating it.

On the operational side, the buildings being constructed today consume significantly less energy to heat, cool, and power than those built in previous decades. Passive design, which uses orientation, insulation, glazing ratios, and thermal mass to reduce mechanical energy demand, has moved from an architectural niche to mainstream practice in many markets. Building automation systems now continuously optimise energy use based on occupancy patterns, outdoor temperatures, and grid signals. Countries including Denmark, Germany, and Singapore have implemented building energy codes that push new construction toward near-zero operational emissions as standard, rather than as an optional premium.

Material innovation has moved at a comparable pace. Cement production, responsible for around 8% of all global CO_2 emissions, has seen significant investment in supplementary cementitious materials (SCMs), including fly ash, slag, and calcined clays, which can partially replace Portland cement clinker and reduce the carbon intensity of concrete mixes by 20 to 30%. New approaches, including geopolymer concrete and electrochemical cement production methods being pioneered by companies such as Sublime Systems, promise to eliminate the calcination process entirely, which currently accounts for roughly half of cement's CO_2 footprint. Engineered mass timber products, particularly cross-laminated timber (CLT), have demonstrated the capacity to store carbon rather than emit it, while studies from Edinburgh Napier University and peer-reviewed journals suggest CLT can reduce embodied carbon in structural applications by 40 to 75% compared to equivalent reinforced concrete.

These are not marginal changes. They represent a genuine and accelerating shift in how the industry thinks about its material and energy inputs. The reasonable assumption is that this trajectory, continued and expanded, would eventually resolve construction's environmental problem.

The problem is that construction's environmental problem is not primarily one of efficiency.

The Scale Problem

Every day, the world adds approximately 12.7 million square metres of new floor area. That is roughly equivalent to adding the entire built footprint of Paris every week. In 2024, global building floor area expanded by 1.7%, reaching 273 billion square metres. Most of this growth is concentrated in emerging economies: India, Southeast Asia, sub-Saharan Africa, and parts of Latin America, where urbanisation is accelerating at rates Europe and North America reached decades ago, but which those regions took generations to build through.

The scale of this expansion is not incidental. It is the central variable that efficiency improvements must outrun if absolute environmental impact is to decline. In 2022, even as building energy intensity fell by 3.5%, the sector's overall energy demand and emissions rose by 1%, because the additional floor area built that year exceeded what the efficiency gains could offset. A 1% increase in the sector's emissions in 2022 was equivalent, according to UNEP, to adding 10 million more cars to the world's roads.

This is the core of what economists and environmental scientists sometimes call the scale problem, and it mirrors a dynamic observed across the history of industrial technology. When steam engines became more fuel-efficient in the 19th century, their adoption spread so rapidly that total coal consumption rose rather than fell. When vehicle fuel efficiency improved through the latter decades of the 20th century, consumers responded by driving more kilometres, buying larger cars, and choosing homes further from city centres. Total fuel use did not fall in proportion to the per-kilometre gain. The logic is structurally identical in construction: each improvement in building performance frees up economic space for more building, and the total burden continues to grow.

The scale problem is compounded by the geography of future construction. According to IEA data, 70% of the buildings projected to exist in Africa by 2040 have not yet been built. A similar dynamic applies to large parts of South and Southeast Asia. These regions will construct their built environments primarily over the next two to three decades, under economic conditions that make low-carbon premium materials and certification processes difficult to mandate or finance. Over 50% of the floor area added globally in 2023 was built without any applicable energy codes in place. The efficiency success story is largely a story of already-wealthy markets improving incrementally. The next chapter of global construction is being written under very different conditions.

Vertical Design and Urban Density

One of the most commonly cited responses to urbanisation pressure is density: build taller, fit more people per hectare, reduce urban sprawl, and cut the transport emissions that come from low-density suburban expansion. The logic is sound in principle. Compact cities do reduce per-person transport emissions, and dense residential zones support more efficient public infrastructure. These benefits are real.

What the argument often overlooks is the lifecycle carbon cost of building tall, as opposed to simply building dense. Research published in npj Urban Sustainability examined four urban configurations, high-density high-rise, low-density high-rise, high-density low-rise, and low-density low-rise, and found that taller urban environments generate 154% more lifecycle greenhouse gas emissions than low-rise environments of comparable density. The key finding was that density and height are separable variables: it is possible to achieve high population density through medium-rise development, as central Paris demonstrates, without incurring the embodied carbon penalty that skyscrapers impose.

That penalty is substantial. Skyscrapers require disproportionate quantities of high-strength concrete and structural steel, both extremely carbon-intensive materials. As buildings increase in height, the ratio of structural material to usable floor area rises steeply, because more material is needed to handle lateral loads, wind resistance, and the transfer of vertical forces across greater spans. The same Edinburgh Napier University study found a saving of approximately 365 tonnes of CO_2 equivalent per person when comparing high-density low-rise to high-density high-rise, across the full lifecycle of the buildings involved.

This does not mean tall buildings are categorically unsustainable. In cities where land is genuinely scarce and transportation alternatives are mature, the trade-offs can shift. A skyscraper in central Tokyo or Singapore, well-served by public transport and built on land that cannot otherwise accommodate the same population, may represent a better overall outcome than the sprawl alternative. The point is not that skyscrapers are always wrong, but that they are not automatically the most sustainable response to density pressure, a conclusion that runs counter to the instinctive assumption that taller means more efficient and therefore more sustainable.

The Materials Perspective

Concrete is the second most consumed material on earth after water. The construction sector accounts for nearly 50% of all global material extraction, and the bulk of that extraction feeds the demand for concrete, steel, and aggregate. Understanding why construction's efficiency gains have not translated into proportional environmental improvements requires understanding what happens upstream, before a single building rises.

Cement production alone contributes approximately 8% of global anthropogenic CO_2 emissions, a figure that has remained stubbornly large despite improvements in production intensity. Roughly half of cement's carbon footprint is intrinsic to the chemistry of the calcination process, in which limestone is heated to produce clinker and releases CO_2 as an unavoidable byproduct. This means that efficiency improvements in energy use can only address part of the problem. The rest requires either substituting different materials or capturing and storing the CO_2 that calcination produces, both of which remain expensive and constrained in scale. The Global Cement and Concrete Association has committed to a 20% reduction in CO_2 per tonne of cement by 2030, but meeting that target while serving a growing global market leaves the absolute emissions picture far less improved than the intensity figures suggest.

Steel tells a more nuanced story. Its CO_2 intensity is high at the production stage, around 2.2 kilograms of CO_2 per kilogram of steel produced, but steel is one of the more recyclable materials in construction, with recycled content rates significantly higher than concrete. The challenge is the speed at which new steel demand is growing in rapidly urbanising economies, outpacing the available supply of scrap. For every kilogram of concrete, steel, and aluminium produced, approximately 0.2, 2.2, and 20 kilograms of CO_2 are emitted, respectively. The sheer volume of concrete used dwarfs the others, but the relative intensity of aluminium becomes relevant as its use in facades, windows, and structural systems expands.

Timber, and particularly engineered wood products such as CLT and glulam, present a different profile. They store carbon absorbed during the growth of the source trees, and studies consistently show lower lifecycle emissions than steel or concrete equivalents. However, timber's scalability is constrained by the pace at which forests can be sustainably managed, the geographic concentration of suitable timber resources, and the technical challenges of fire resistance and moisture management in tall timber structures. Timber is a valuable part of the materials picture, but it cannot substitute for concrete and steel at the volumes the sector demands, at least not within the timeframe that matters for climate goals.

The critical insight is that no single material is universally good or bad. What matters is the combination of material choice, application context, durability, and what happens to the material at the end of a building's life. A material that performs well in one dimension, say, lower operational carbon, may perform poorly in another, such as end-of-life recyclability or upstream extraction impact. The lifecycle lens reveals trade-offs that point-in-time comparisons consistently miss.

The Recycling Perspective

Construction and demolition waste represents one of the largest waste streams on Earth. In 2023, the volume reached approximately 2.5 billion metric tonnes globally, with projections pointing toward 3.8 billion metric tonnes by 2033. In the European Union alone, construction and demolition waste accounts for roughly 747 million tonnes annually, or approximately 1,685 kilograms per person. In the United Kingdom, it constitutes around 62% of all waste generated nationally.

Recycling rates within this stream look, on the surface, reasonably high. Many European countries report recycling rates for construction and demolition waste in the range of 70 to 90%. The reality behind those figures is more complicated. The majority of what is counted as recycled concrete is downcycled: crushed into low-grade aggregate for use in road bases, drainage layers, or fill material. The structural integrity required to reuse it as primary concrete aggregate is rarely achievable without significant energy-intensive reprocessing. Steel fares better, as it can be melted and recast without significant quality loss, but only if it is properly separated and not contaminated with coatings, fixings, or other materials during demolition.

Contamination is a persistent and underappreciated barrier. Mixed demolition waste, in which plaster, insulation, timber, fixings, and concrete arrive together at processing facilities, creates sorting challenges that drive up costs and reduce the quality of the recovered materials. The carbon cost of transportation from demolition sites to processing facilities and then onward to new uses adds a further layer of environmental impact that simple recycling statistics do not capture. There is also an economic dimension: recycled materials often compete with virgin alternatives on price only within specific regulatory or procurement frameworks. Outside those frameworks, the economic incentive to use recycled materials is frequently insufficient to overcome the logistical difficulty of obtaining and processing them.

The consequence is that construction recycling, while growing, operates far more as a linear process with a recycling stage appended at the end than as a genuinely circular system in which materials retain their value and quality through multiple cycles. High recycling volumes do not automatically translate into high environmental performance if the quality of what is recovered declines with each cycle and the total volume of waste continues to rise.

Sustainable Design

The limitations of end-of-life recycling point toward a fundamentally different design philosophy, one in which a building's disassembly is considered from the moment it is designed, rather than treated as an afterthought at the moment of demolition.

Design for Disassembly (DfD) is a set of principles that seeks to engineer buildings with reversible connections, modular components, and standardised systems that allow materials to be recovered intact rather than destroyed during demolition. Instead of concrete poured around steel in ways that make separation impossible without crushing, DfD approaches use bolted connections, demountable floor systems, and prefabricated modules that can be uninstalled, transported, and reinstalled elsewhere. The ambition is to treat a building not as a product with a single lifecycle but as a temporary custodian of materials that have their own ongoing value.

Material passports are the informational infrastructure that makes this possible at scale. A digital material passport records what a building is made of: the composition of its structural elements, the location of hazardous substances, the grade and origin of its steelwork, the type of adhesives used in its facade panels, and the reversibility of its connections. Without this information, the default outcome at demolition is mixed waste, because neither the demolition contractor nor the secondary materials market knows enough about what is being destroyed to value it. With it, materials can be traded, reused, or recycled at the highest possible quality level.

Several pioneering projects illustrate what this looks like in practice. The Triodos Bank headquarters in the Netherlands, completed in 2019, was constructed using timber and steel components connected entirely with bolts rather than adhesives, allowing the building to be fully disassembled at the end of its life and every major element to be reused. Each component carries a material passport registered on a digital platform, so the identity, condition, and residual value of the materials are tracked continuously. The structure has been described as a materials bank rather than a building, an institution that holds assets temporarily rather than consuming them permanently.

In Belgium, the organisation Rotor has spent over a decade demonstrating that salvaged building components, from structural steel to sanitary fittings, can be professionally recovered and resold at commercially viable prices when demolition is planned carefully rather than executed at speed. Their work has shifted the conversation in Brussels from waste management toward urban mining: the systematic extraction of value from the existing built environment rather than the extraction of new raw materials from the ground.

These approaches remain at the frontier of the industry rather than its mainstream. Cost, coordination between design, construction, and future demolition teams, and the absence of robust secondary markets for recovered building components all limit uptake. However, the European Union's anticipated Digital Product Passport mandate, which will require building materials to carry traceable identity records, may shift the economics significantly. The direction of travel is clear, even if the pace remains uncertain.

Comparative Data Analysis: Efficiency vs. Scale in Construction

The figures below draw on peer-reviewed research, UNEP and GlobalABC annual reports, and industry data to place efficiency gains alongside their scale counterparts, revealing why the sector's environmental footprint has not declined in proportion to its technological progress.

Dimension	Efficiency Gain	Scale Counter-Effect	Net Trend
Building energy intensity	-8.5% over the last decade	+1.7% global floor area in 2024 alone	Absolute demand rising
Sector CO_2 emissions	Operational intensity is falling in the OECD	10 Gt CO_2 in 2023; up 5% since 2015	Not on the Paris pathway
Cement production	SCMs reduce intensity by 20-30%	8% of all global CO2 from cement alone; demand growing with urbanisation	Gross emissions largely stable
C&D waste generation	Recycling market expanding	2.5 billion metric tonnes in 2023; most concrete downcycled to low-grade aggregate	Volume climbing, quality falling
High-rise vs low-rise embodied carbon	High-rise operational efficiency gains	+154% lifecycle GHG emissions vs low-rise (high density)	Density without height is better

Green building certifications	Nearly tripled in a decade	Certified floor area is still a minority of new build; >50% of 2023 builds without energy codes	Progress, but far from mainstream
Investment alignment	USD 275 billion in efficiency (2024)	Needs USD 5.9 trillion by 2030 for net-zero; only 4% of construction spending is Paris-aligned	Investment gap widening

Table 1: Synthesised comparison of efficiency gains and scale effects in global construction. Sources: UNEP/GlobalABC Global Status Report 2024-25; GlobalABC Global Status Report 2024 (Beyond Foundations); npj Urban Sustainability (Pomponi et al., 2021); NREL State of Innovation 2024; McKinsey (2023); Global Insight Services C&D Waste Market Report (2024).

The pattern that emerges from this comparison is consistent across every dimension examined. Wherever the industry has achieved genuine efficiency improvements, an expansion in scale has partially or wholly offset the environmental benefit at the aggregate level. Building energy intensity falls, but floor area grows faster. Cement production becomes less carbon-intensive per tonne, but global demand for cement continues to rise with urbanisation. Recycling rates for construction waste improve, but the total volume of waste generated expands more rapidly than the recycling infrastructure can process. Green building certifications nearly tripled, but certified buildings remain a minority of new construction globally, and over half of all new floor area added in 2023 was built without applicable energy codes.

This is not a story about the failure of innovation. It is a story about the relationship between innovation and demand. When efficiency improves without any constraint on total volume, the environmental savings generated per unit tend to be consumed by growth in the number of units. The construction sector will not escape this dynamic through innovation alone.

Conclusion

It would be a mistake to conclude from this analysis that efficiency improvements in construction do not matter. They do. Buildings that consume less energy to operate reduce emissions over their lifetimes in ways that compound across decades. Materials with lower embodied carbon impose a smaller initial burden on the atmosphere. Better recycling systems reduce the extraction of virgin resources. None of this is trivial, and the industry deserves recognition for the genuine progress it has made.

The mistake is in treating efficiency as sufficient. The environmental future of construction depends on a simultaneous advance across at least five dimensions: how efficiently each building performs, how much we choose to build in total, what materials we choose to build with, how we design those buildings for eventual disassembly and material recovery, and how we connect the end of one building's life to the beginning of the next. Efficiency addresses the first dimension. The others require a different kind of thinking entirely.

The most important reframe is this: a building is not a product. It is a temporary arrangement of materials, energy, and capital. The question that the construction industry has historically asked at the end of a building's life is what do we do with the waste? The question it needs to learn to ask at the beginning is where will these materials go next? Designing for disassembly, tracking materials through their lifecycles, and building systems that allow components to be recovered at full quality rather than crushed into fill: these are not the inevitable outputs of an efficient construction industry. They are deliberate choices that require a fundamentally different relationship between the way we design, build, demolish, and rebuild.

The construction sector will build more in the next thirty years than it has built in all of human history before now. Most of that construction will happen in regions where regulatory capacity is limited, financing is constrained, and the pressure to build quickly and cheaply is intense. Whether that era of construction becomes an environmental catastrophe or an opportunity to embed a genuinely circular approach to the built environment depends on choices that are being made now, in design offices, procurement policies, regulatory frameworks, and financing structures. Efficiency helps. It is not enough.

When Construction is Sustainable:

- When new buildings are designed with their end-of-life in mind, using material passports, reversible connections, and modular systems that allow components to be recovered intact rather than crushed into lower-grade waste.
- When building energy codes are updated to reflect zero-emissions building principles, and when those codes are enforced in the markets where the majority of new floor area is being added, not only in markets where construction volumes are already modest.
- When low-carbon material alternatives, including engineered timber, supplementary cementitious materials, and recycled steel, are integrated not as premium options for certified projects but as standard practice in procurement and specification processes.
- When urban planning explicitly favours high-density, medium-rise development that achieves population capacity without the disproportionate embodied carbon burden of skyscraper construction.

When It's Not:

- When efficiency improvements in individual buildings are used to justify continued expansion of total construction volume, without accounting for whether the absolute environmental burden of that expansion is being managed.
- When recycling statistics are presented without distinguishing between genuine material recovery and downcycling, obscuring the true quality and longevity of what is being recovered.
- When design, construction, and demolition are treated as separate industries with separate incentives, rather than as sequential phases of the same material lifecycle that need to be planned together from the outset.
- When the framing of green building as a market premium rather than a baseline standard allows the majority of global construction to proceed without meaningful engagement with its environmental impacts.
- When urbanisation pressure in developing economies is used as an argument to delay rather than accelerate the adoption of building codes, low-carbon materials standards, and

circular construction principles in the markets where the greatest volume of future construction will take place.

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